A SYSTEMATIC APPROACH TO ABNORMAL CHEST IMAGES: RADIOGRAPHS AND COMPUTED TOMOGRAMS

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I. DEFINITIONS

A. Pattern - Seen on images
B. Disease - Seen on specimens
C. Diffuse pulmonary disease
    Nonspecific term for either destructive restrictive pulmonary disease involving all or most of the lung fields producing any pattern of opacity on chest films and CT.
D. Infiltrative lung disease
    Nonspecific term for any restrictive pulmonary disease which infiltrates rather than destroys lung parenchyma.
E. Interstitial lung disease
    Pathology term for thickening or destruction of pulmonary interstitium, which includes alveolar walls, septa and connective tissue surrounding bronchi and vessels (peribronchial and perivascular spaces). Correlates with functional term “restrictive lung disease” and with interstitial pattern on chest films.
F. Consolidative Pattern
    Preferred over ‘alveolar pattern’ to describe the radiological pattern of filled air spaces.

II. PATTERNS

A. Mass
B. Consolidative
C. Interstitial
    1. linear
    2. nodular
D. Vascular
E. Airway
    1. obstructive
    2. wall thickened

III. MASS

A. Mechanism - Local destruction of lung parenchyma
B. Radiological Sign - Any localized opacity not completely bordered by fissures or pleura

C. Differential Diagnosis
    1. Malignancy – Primary, metastatic, lymphomatous
    2. Granulomatous disease - infectious or noninfectious, active or inactive.
    3. Other inflammation, including pneumonia and abscess
    4. Benign neoplasm
    5. Congenital abnormality
D. Crucial appearance characteristics for inactivity
    1. Calcification - Central, lamellar
    2. Evolution - 2 year stability or regression
E. Clinical variables
    1. Age
    2. Symptoms and signs
    3. Risk factors
        - Smoking
        - Occupation, exposure
        - Previous carcinoma
        - Concurrent diseases

IV. CONSOLIDATIVE (ALVEOLAR) PATTERN

A. Mechanism
   produced in pure form only by alveolar filling, but may mimicked by alveolar collapse. airway obstruction, or rarely confluent interstitial thickening, or a combination of these.
B. Radiological signs
   Fluffy, cloud-like, coalescent opacities which may have sharp edges when limited by fissures or pleura. Complete air bronchograms unless airways obstructed.
C. Differential Diagnosis
    1. Hemorrhage - Blood - Embolism, trauma
    2. Exudate - Pus - Pneumonia, pneumonitis
    3. Transudate - Water - Congestion, ARDS
    4. Secretions - Protein - Mucous plugging, alveolar proteinosis
    5. Malignancy - Cells - Alveolar cell carcinoma, lymphoma

D. HRCT appearance – may be same density as blood or may be ground-glass
GROUND-GLASS density favors ACTIVE process over chronic and MILD over severe

Mechanisms:

Consolidative pattern with diffuse aerated alveoli
Severe interstital pattern
Fatty material in consolidated alveoli
Obstructive pneumonitis or alveolar proteinosis
Vascular plethora – often mosaic

V. INTERSTITIAL PATTERN

A. Mechanism
Diffuse or irregular thickening of lung interstices or architectural destruction of interstitium (honeycomb or "end stage" lung).

B. Radiological Signs

1. Linear form
Characterized by reticulations (lines in all directions and by septal lines (Kerley lines).
2. Nodular form
Characterized by small, sharp, numerous, evenly distributed, uniform (especially uniform in shape) nodules
3. Destructive form
sole distinctive feature is peripheral, irregular formation

C. Additional linear signs with CT (especially HRCT)

1. Peribronchial thickening
2. Perivascular thickening
3. Alveolar wall thickening
4. Subpleural thickening
5. Thick-walled cystic spaces (honeycomb)

D. Differential diagnoses:

1. Linear form - LIFE lines
- Lymphangitic spread of malignancy
- Inflammation
- Fibrosis
- Edema

2. Nodular form
- Granulomas
- Hematogenous spread of malignancy
- Pneumonoconiosis

3. Destructive form
    - Fibrosing aveolitis (IPF, UIP)
    - Specific causes of fibrosis

E. HRCT distribution of linear interstitial patterns:
    - L central
    - I diffuse or lower lungs
    - F peripheral
    - E central, with dilated vessels

F. Destructive form

Characterized by permanent lung destruction with architectural distortion of the parenchyma. Early appearance is nonspecific, usually identical with linear form. Late findings include peripheral cystic spaces ("Honeycomb" or "End Stage Lung") and irregular reticulations with volume loss and deformity of lungs. Most easily seen with HRCT.

VI. VASCULAR PATTERNS

A. Mechanism

Caused by increased, or decreased perfusion, altering diameter of pulmonary vessels.

B. Radiological Signs

Changes in diameter of specific vessels.

C. Common Examples:

1. Congestion - engorged veins, especially upper lungs
2. Emphysema - diminished vessels
3. Arterial hypertension - large central arteries with peripheral tapering
4. Thromboembolism - locally diminished vessels with possible vessel mass centrally located
5. Shunt vascularity - All vessels enlarged
6. Bronchial circulation - Irregular vessels in unusual directions
7. Lymphangitic carcinoma - Irregular infiltration around vessels may resemble vessel enlargement

VII. AIRWAY (BRONCHIAL) PATTERNS

A. Mechanism
Caused by complete or partial obstruction of airways or by thickening of airway walls.

B. Forms
1. Complete airway obstruction - Produces opacity and decreased volume of lung distal to the site of obstruction. May resemble localized consolidation, but without air bronchograms
2. Partial obstruction - Produces lucency and increased volume by air trapping
3. Wall thickening - Tram tracks, central cystic spaces or circles

C. Differential Diagnosis
1. Opacities - Endobronchial neoplasms, granulomas, inflammatory, benign or congenital masses, mucous plugs, foreign bodies.
2. Lucencies - COPD, cysts, blebs, pneumatoceles
3. Thickening - Bronchiectasis, chronic bronchitis

D. Additional Signs with CT
1. Thick-walled airways, circular on end, often “signet rings”
2. Cystic spaces centrally located
3. Cystic spaced with very thin walls or no apparent walls
4. Thin, stretched vessels
5. Bronchiectasis

E. Destructive Airway Disease - Bronchiectasis
1. Characterized by central (perihilar) cystic spaces, increased lung volumes and thickened airway walls (circles, when seen on end, and tram tracks)
2. Distinct from destructive interstitial disease (see V. E.), although some patients also have secondary interstitial changes, especially localized fibrosis.

F. Small Airway Disease
1. Often appears as “mixed pattern” of patchy opacities and lucencies, also called “alveolar nodules”
2. Usually includes bronchiolitis, producing complete and partial obstructions of small airways
3. Causes of bronchiolitis
    a. Infectious - eg. viral, mycoplasmal
    b. Allergic
    c. Toxic - eg. chlorine, phosgene
    d. Idiopathic
4. May thicken bronchial walls and resemble interstitial reticulations.

TABLE I

BASIC DIFFUSE PULMONARY PATTERNS

Consolidative
Interstitial
- Linear
- Nodular

Vascular
Airway
- Obstructive
- Wall thickened

TABLE II

INTERSTITIAL PATTERNS

Differential Diagnosis

Linear form — LIFE lines
- Lymphangitic spread of malignancy
- Inflammation
- Fibrosis
- Edema

Nodular form
- Granulomas
- Hematogenous spread of malignancy
- Pneumoconiosis

Destructive form — Honeycomb (“end stage”) lung

TABLE III

CAUSES OF LINEAR INTERSTITIAL PATTERNS

Lymphangitic Spread
- Metastatic malignancy
- Primary malignancy (usually adenocarcinoma)
- Lymphoma (rarely)
- Sjögrens Syndrome (rarely)
- Lymphangioleiomyomatosis (rare)

Inflammation
- Infections
- Viral
- Mycoplasmal
- Bacterial (usually early or mild)
- Pneumocystis carinii
- Collagen Vascular Disease
- Rheumatoid arthritis
- Polymyositis and dermatomyositis
- Scleroderma (progressive systemic sclerosis)
- Allergic alveolitis (hypersensitivity pneumonitis)
- Drug reactions
- Waldenström macroglobulinemia
- Amyloidosis
- Idiopathic (“usual interstitial pneumonitis”)

Fibrosis
- Following inflammation (see above)
- Asbestosis
- Radiation pneumonitis
- ? Talcosis
- Neurofibromatosis

Edema
- Cardiac
- Renal
- Fluid overload
- Anemia

Table IV

CAUSES OF NODULAR INTERSTITIAL PATTERNS

- Granulomatous Diseases
  - Infectious
    - Tuberculosis
    - Atypical mycobacterial diseases
    - Fungal diseases, especially:
      - Histoplasmosis
      - Coccidioidomycosis
      - Blastomycosis (N. A. and S. A.)
      - Cryptococcosis
      - Sporotrichosis
    - Bacterial diseases, especially:
      - Nocardiosis
      - Actinomycosis
  - Non-infectious
    - Sarcoidosis
    - Vasculitis-granulomatosis diseases
      - Wegener's
      - Lymphocytic
      - Bronchocentric
      - Allergic (Churg-Strauss)
    - Histiocytosis (eosinophilic granuloma) (LCG)
- Hematogenous Metastases
- Pneumoconioses
  - Granulomatous
    - Silicosis
    - Berylliosis
  - "Benign"
    - Coal Worker's Pneumoconiosis
    - Siderosis
    - Stannosis

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